

## THE WEATHER AND CIRCULATION OF OCTOBER 1966

### Cool Weather With Strong Polar Blocking

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#### 1. MONTHLY MEAN FEATURES

##### CIRCULATION

Strong blocking in very high latitudes partially controlled the mid-tropospheric circulation and surface weather over most of the United States and Canada during October 1966. Some measure of the strength of the blocking may be seen in the polar index as determined from the flow in the western portion of the Northern Hemisphere from  $55^{\circ}$  N. to  $75^{\circ}$  N. At the 700-mb. level polar westerlies were 1.8 meters per second below normal and at the surface polar easterlies were 2.2 m.p.s. above normal. The blocking appeared strong in consideration of the mean 700-mb. flow for October (fig. 1) and the 700-mb. height anomaly flow (fig. 2). The former chart shows a ridge over Greenland and another north of Alaska. But the height anomaly chart defines the blocking much better: 700-mb. heights were as much as 300 ft. above normal in Denmark Strait with positive heights extending in an arc to the Beaufort Sea.

Other affiliated effects of the blocking include negative height anomaly centers near the Bay of Biscay and near James Bay. Negative heights northwest of James Bay were also related to blocking, probably in response to the strong easterly anomalous flow across the Canadian Arctic which encourages westerly anomalous flow to the south. This in turn inhibits ridging that would normally exist between the Low in Alaska and the trough over North America. Thus the control by blocking resulted in actual and anomalous flow over the United States dominantly from maritime areas. Since the ridge was weaker than normal with very little amplitude there was little chance for sustained outbreaks of continental air masses. In fact, the principal track of Highs this month was from the Pacific to the Great Basin, thence to the Southern Plains and across the Middle Atlantic States (see chart VIII of [1]). Only one High from the Canadian Arctic affected the United States in any appreciable strength.

Height anomaly changes from September to October (fig. 3) show slight rises over most of the United States with some decreases in the Northern Plains and as much as 200 ft. decreases in western Canada. This suggests increased westerly flow but blocking is not necessarily implied.

The next long-wave trough downstream from North America extended from the United Kingdom to northwestern Africa with negative height anomalies over much of Europe and the eastern Atlantic. Height changes (fig. 3) were typical of blocking with marked increases in northerly latitudes and decreases south of  $60^{\circ}$  N. These changes reflect a major circulation reversal from September [2] as anticyclonic flow was replaced by cyclonic flow in October. This new trough developed with the growth of blocking over Greenland. Meanwhile readjustment of the long-wave pattern to compensate for this trough occurred in the following manner: the trough formerly along the east coast of North America moved westward about  $15^{\circ}$ , and the trough along  $40^{\circ}$  E. in September moved to  $70^{\circ}$  E.

Over eastern Asia westerly flow was split with one branch moving northeastward near  $60^{\circ}$  N. and another moving southeastward to the Sea of Japan. This is indicative of the blocking that formed here in October. Heights at 700 mb. in the Sea of Okhotsk increased by more than 400 ft. from September to October (fig. 3) and anticyclonic curvature replaced cyclonic. The trough having filled in the north retrograded somewhat and was lower than normal only from the southern Japanese islands westward.

In the central Pacific the trough position changed little from September to October but its intensity decreased as anomalous heights increased by more than 300 ft. in the Gulf of Alaska and near Kamchatka. These changes accompanied a notable decrease in the temperate-latitude zonal flow.

##### TEMPERATURE

Persistence of monthly temperature from September to October was unusually strong this year. Of 100 cities across the Nation the temperature at 85 changed by no more than one class (of five). At this time of year average persistence is usually decreasing from a maximum of 80 percent for July-August to 67 percent for September-October to a minimum for the year of 56 percent in November [3]. Significant changes were noted in Idaho and portions of neighboring States where temperature anomalies decreased by 2 or 3 classes from September to October.



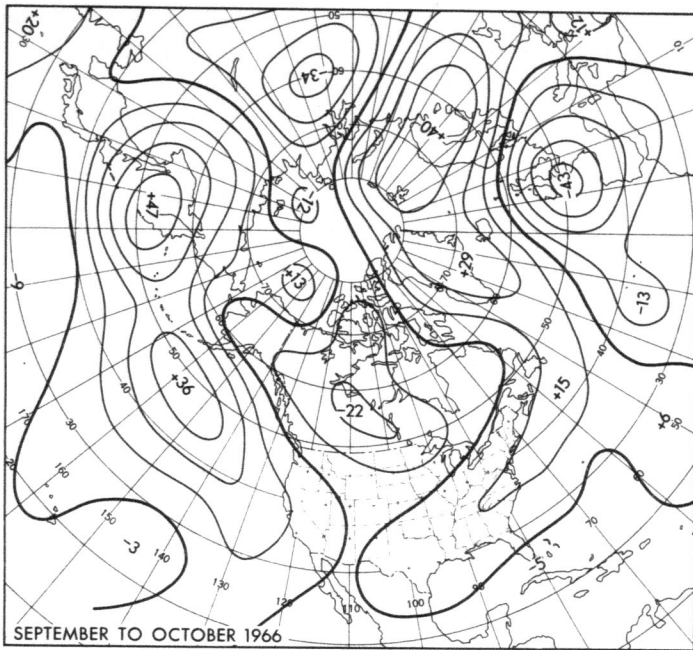


FIGURE 3.—Mean 700-mb. height anomaly change (tens of feet) from September to October 1966. Height increases in the south and decreases in the north support the increased zonal flow from September to October in northern United States and southern Canada.

Temperatures were lower than normal over most of the continental United States (fig. 4) with only a few areas higher than normal. This relatively cool weather also was a characteristic pattern during August [4] and September [2]. The West was warm in August and September but in October erosion of the 700-mb. ridge in this area was accompanied by some decrease in warmth with temperatures at a few stations averaging  $2^{\circ}$ – $4^{\circ}$  F. below normal.

Cooler than normal weather in the eastern half of the Nation was near the 700-mb. trough (figs. 1 and 2). Heights were 100 ft. below normal from New England to Minnesota but where negative temperature anomalies were greatest ( $2^{\circ}$ – $4^{\circ}$  F. below normal) heights were 50 ft. or less below normal. Average 1000–700-mb. thickness was near normal over this cool area that extended from Texas to the Middle Atlantic States. This lack of correspondence between surface temperature and thickness or height anomaly can sometimes be attributed to precipitation.

#### PRECIPITATION

Precipitation was heavier than normal this month (fig. 5) in portions of the Northern Plains, central Rockies, and the eastern one-fourth of the Nation. Continued dryness this month at Helena, Mont., and Wichita, Kans., made the first 10 months of 1966 the driest such period of record. In contrast to dryness elsewhere New Orleans had 115 percent of its normal annual rate by the end of October.

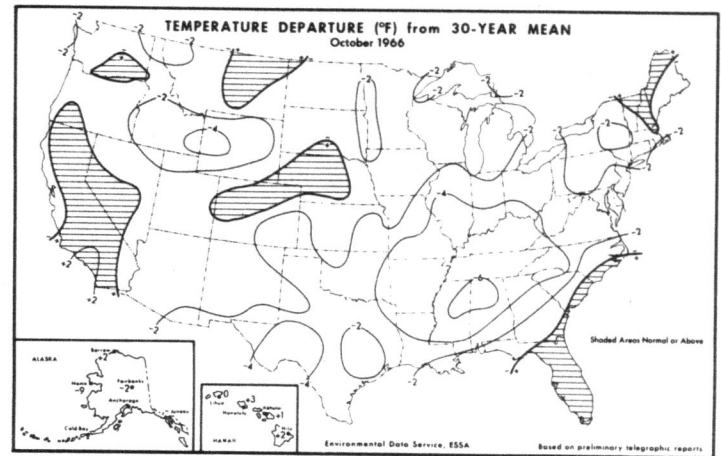


FIGURE 4.—Departures of average surface temperature from normal ( $^{\circ}$ F.) for October 1966 (from [5]). Cooler than normal conditions persisted this month with little change from September except for much cooler in portions of the northern Rockies and Great Basin.

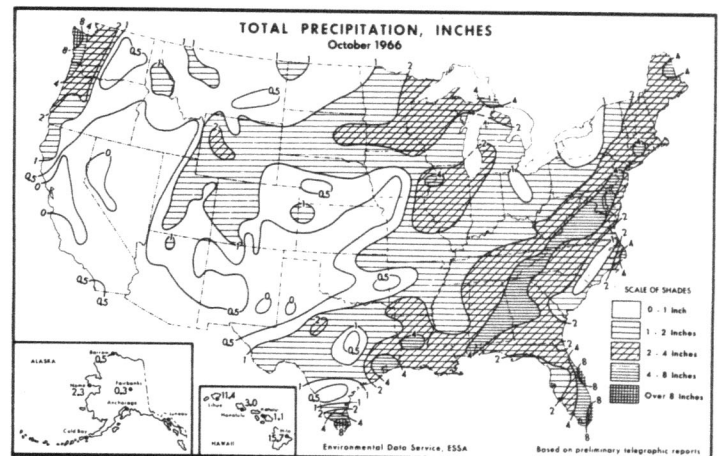


FIGURE 5.—Percentage of normal precipitation for October 1966 (from [5]). Heavy precipitation in the East seemed to correspond to the mean 700-mb. flow better than the heavy precipitation in the Plains.

Heavy precipitation in portions of the South and East was as much as twice normal. In the Northeast 2–4 in. of precipitation was near or slightly less than normal. However, this lessened the severity of the drought with extreme conditions now confined to central Pennsylvania [5].

The monthly mean trough extending from the lower Mississippi Valley to eastern Canada suggests the likelihood of widespread heavy precipitation from Illinois to Pennsylvania and New York instead of the observed light to moderate. Apparently the East was not exposed to sustained flow from either of the nearby moisture sources, the Gulf of Mexico or the Atlantic Ocean. Actual 700-mb. flow (fig. 1) and sea level flow (see Chart X of [1]) suggests a mean trajectory from continental areas.

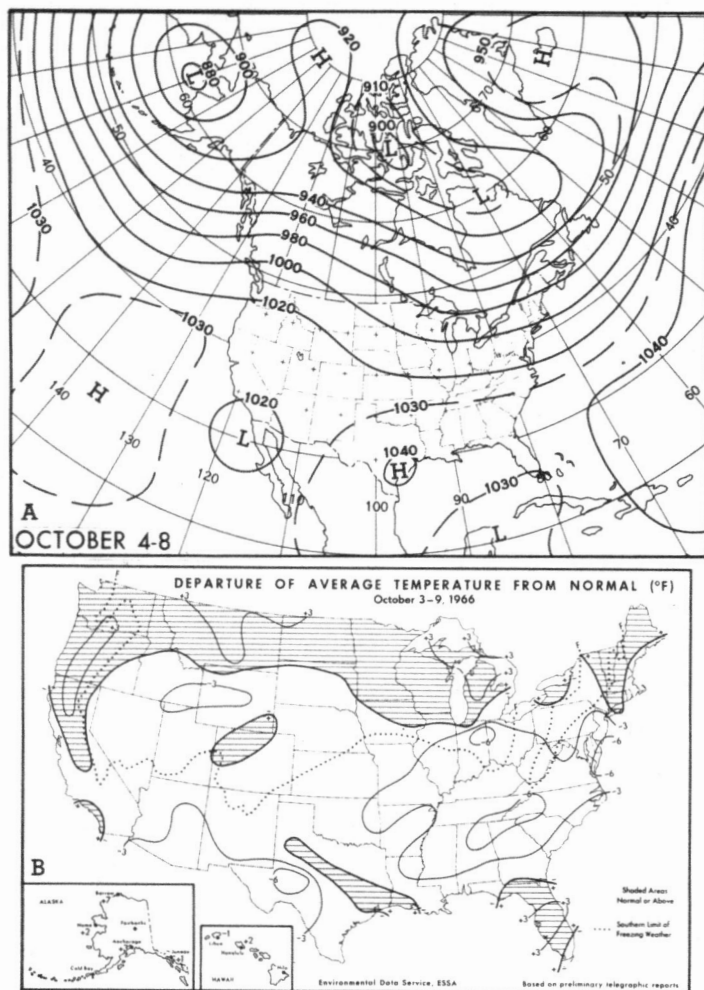


FIGURE 6.—(A) Mean 700-mb. contours (tens of feet) for October 4-8, 1966; (B) Departure of mean surface temperature from normal (° F.) for October 3-9, 1966 (from [5]).

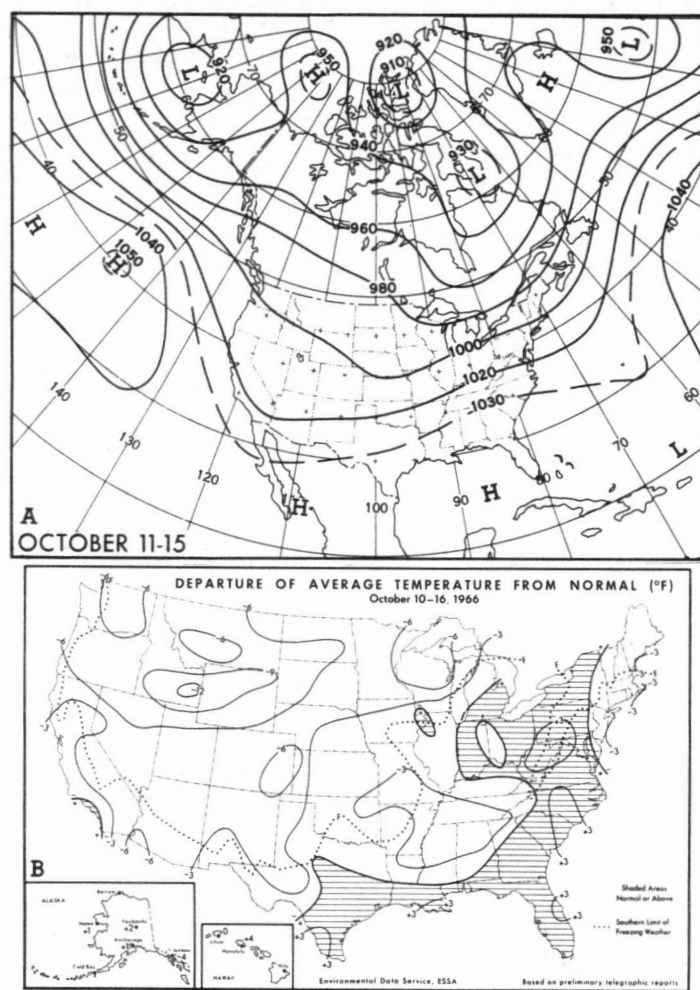


FIGURE 7.—(A) Mean 700-mb. contours (tens of feet) for October 11-15, 1966; (B) Departure of mean surface temperature from normal (° F.) for October 10-16, 1966 (from [5]).

The band of heavy precipitation from Alabama to New England coastal areas was nearly coincident with a secondary branch of the mean 700-mb. jet (not shown). Along this zone was a secondary cyclone track composed of two fast-moving storms, one early in the month and another during the third week.

## 2. WEEKLY CIRCULATION CHANGES AND WEATHER

### OCTOBER 3-9

Fast zonal flow characterized the 700-mb. circulation this week over North America and adjacent ocean areas (fig. 6A). The ridge in western North America was somewhat higher than normal and the trough in eastern North America was 400 ft. below normal near Labrador as the vortex here became interrelated with the blocking over Greenland.

Heights over the United States departed only slightly from normal except in New England where the trough was 200-300 ft. below normal. The strong westerly flow pro-

duced a temperate-latitude zonal index ( $5^{\circ}$  W.- $175^{\circ}$  E.) of 12.1 m.p.s., more than 3 m.p.s. above normal. The effect of this strong flow on temperature in the United States is shown in figure 6B. Normal to above normal temperatures were confined to States along the Canadian border and to Pacific Coast States near the upper-level ridge.

A surface cyclone early in the week swept through the Central and Northern Plains States (see chart IX of [1]) with up to a foot of snow in the northern Rockies and 2 in. or more of rain in Texas. The subsequent cold outbreak was responsible for below normal temperatures in the southern two-thirds of the Nation. With the approach of another perturbation, temperatures changed fast in the Northern Plains from  $30^{\circ}$  F. or below on Wednesday to  $80^{\circ}$  F. or higher on Thursday. Another vigorous cold front at the end of the week caused 3-5 in. of rain in portions of Alabama and Georgia. A new 24-hr. total for October (2.45 in.) was established at Macon, Ga.



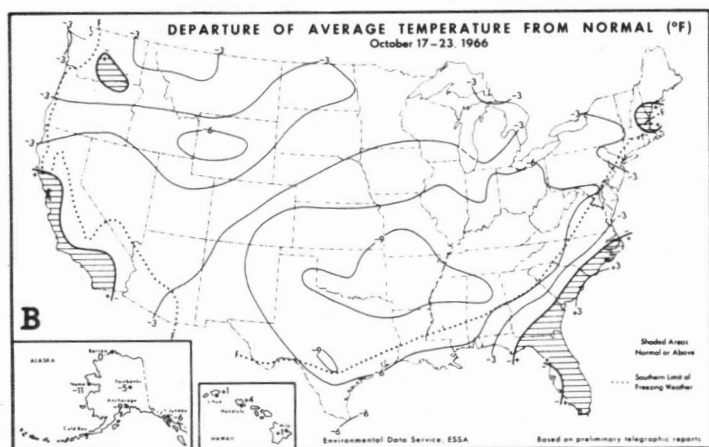
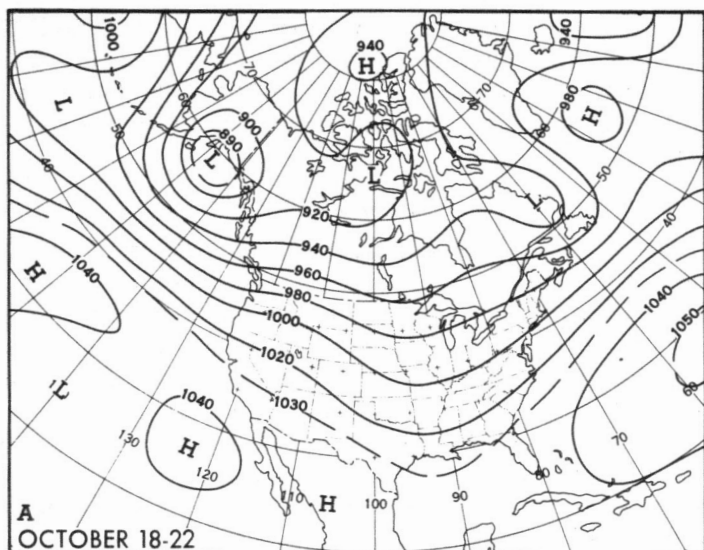


FIGURE 8.—(A) Mean 700-mb. contours (tens of feet) for October 18-22, 1966; (B) Departures of mean surface temperature from normal ( $^{\circ}$  F.) for October 17-23, 1966 (from [5]).

Hurricane Inez caused heavy rain in southern Florida while moving from the Bahamas through the Straits of Florida and across the Keys. The storm moved southwestward to the Yucatan coast then westward to the central Mexican coast (see daily positions in [2]). As shown in figure 6A the 5-day average circulation along the storm path showed an easterly trough. But to the north a ridge near  $30^{\circ}$  N. prevailed from the western Atlantic to northern Mexico. Five-day mean 700-mb. height anomaly charts (not shown) showed negative height anomalies north of the storm while it was moving north. After October 3 when Inez started westward, height anomalies north of the hurricane were greater than normal as the westerlies moved farther north.

#### OCTOBER 10-16

Amplification of the flow this week (fig. 7A) dominated the mean 700-mb. circulation. Ridging occurred in the eastern Pacific and in the central Atlantic with a hint of

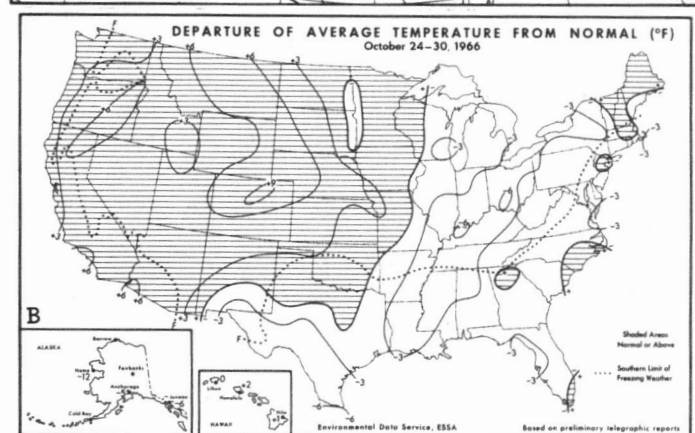
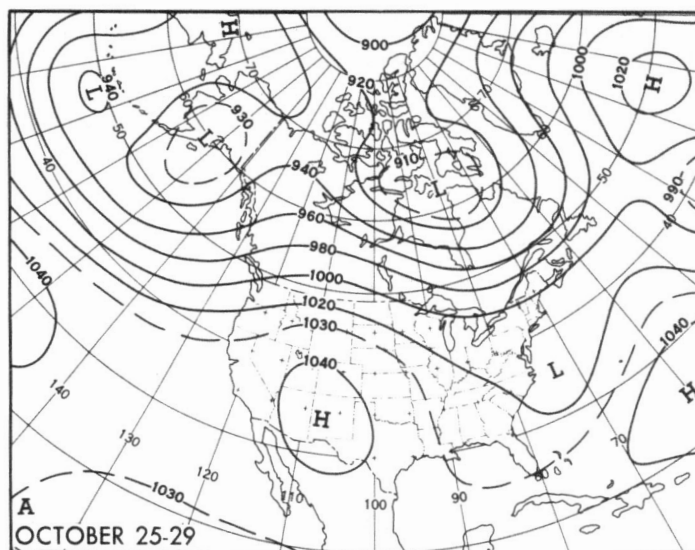


FIGURE 9.—(A) Mean 700-mb. contours (tens of feet) for October 25-29, 1966; (B) Departure of mean surface temperature from normal ( $^{\circ}$  F.) for October 24-30, 1966 (from [5]).

blocking over northern Canada. Troughing spread over the United States except for a small ridge in the Southeast. This represents essentially a retrogression of the trough over North America by extension of marked troughing over the West. Meanwhile the zonal index decreased to near normal.

Temperature reaction to this circulation evolution is shown in figure 7B. Temperatures averaged a few degrees above normal in the East in response to some ridging here as the trough deepened in the West. The western two-thirds of the Nation cooled considerably as daily temperatures decreased in the Central Plains from the 80's and 90's to the 40's and 50's with the most severe cold spell thus far in the season. Temperatures averaged  $3^{\circ}$ - $6^{\circ}$  F. below normal over a broad area from the Mississippi Valley westward and were  $9^{\circ}$ - $12^{\circ}$  F. below normal in the northern Rockies. Lowest temperatures of the week were below  $0^{\circ}$  F. at one or more stations in

Colorado and Wyoming. Snow accumulated to 18 in. in some parts of the central Rockies. Record 24-hr. snowfall for October (19.4 in.) was reported at Lander, Wyo., while Goodland, Kans., had its heaviest snow of any October (6.4 in.), and Duluth, Minn., (7.9 in.) its heaviest so early in the season.

The cold front preceding this cold weather was particularly strong and was accompanied by severe local storms. Tornadoes occurred in Minnesota, Iowa, and Missouri, and strong, gusty winds elsewhere along the front to Texas. Rainfall associated with this front amounted to 2-4 in. in the Upper Mississippi Valley and along the Gulf Coast.

#### OCTOBER 17-23

Progression of upper-air features characterized the flow this week (fig. 8A) as blocking near Greenland strengthened. The deep Low formerly in the Bering Sea moved to the Gulf of Alaska and the ridge preceding this system moved into western North America. This ridge weakened considerably, and the strengthened westerly flow forced the trough from the Southwest into the Mississippi Valley. Anomalous 700-mb. heights were negative except in the Far Southwest where heights were less than 100 ft. above normal.

Temperatures were below normal over the Nation with only coastal areas of the Southeast and California slightly above normal (fig. 8B). Coldest weather relative to normal ( $-9^{\circ}\text{F.}$ ) was centered over Arkansas with quite low average temperatures from Texas through the Ohio Valley. Records this week included  $18^{\circ}\text{F.}$  at Pueblo, Colo., a new minimum for October, and  $34^{\circ}\text{F.}$  at San Antonio, Tex., a new low for so early in the season.

Substantial precipitation this week was confined to coastal Washington and Oregon (2-3 in.) and the eastern one-third of the Nation. In the latter area 2-3 in. of precipitation fell from northern Georgia along the Appalachians to Virginia, then east of the mountains from Maryland to Connecticut. This precipitation occurred as a trough deepened in the Gulf of Alaska and a short wave moved out of the Southwest. As this daily upper-level perturbation reached the mean trough precipitation became heavier. The surface storm that was associated with the short-wave trough formed in southern Mississippi, deepened off the New England coast, and moved rapidly into the mean 700-mb. center of action over Labrador. Record 24-hr. precipitation (3.46 in.) was reported at Trenton, N.J. Near the end of the week another storm

deepened over Minnesota, having moved out of the Gulf of Alaska. This storm produced very little precipitation after reaching the Rockies, but its intense circulation was accompanied by cool air that reached from Minnesota to Texas by the end of the week.

#### OCTOBER 24-30

Rather strong amplification of the 700-mb. flow occurred this week over and near North America (fig. 9A). Deepening in the western Aleutians was concurrent with filling in the Gulf of Alaska and pronounced ridging over western North America. In the Northern Plains and adjacent areas of Canada anomalous 700-mb. heights increased 400-500 ft. this week. The temperate-latitude zonal index reflected the amplification as it dropped to the lowest 5-day value of the month, 1.2 m.p.s. The blocking ridge was less active from Greenland to the Beaufort Sea but much stronger in the North Atlantic. Here heights were more than 500 ft. above normal between southern Greenland and the United Kingdom.

Marked warming spread over the western half of the Nation this week (fig. 9B) under the strong upper-level ridge that was 300 ft. above normal in the Dakotas. Some warming was observed from the Mississippi River eastward but temperatures remained several degrees below normal. A strong continental surface High spread cold air from the Northern Plains to the east coast at the end of the week. This air mass was modified rather quickly as a new cyclone entered the Northern Plains on Sunday.

Precipitation was very light this week with none over most of the Nation, a frequent condition in October.

#### REFERENCES

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